APPLICATION OF COMMON MODE OPERATION TO CENTRAL OFFICE EQUIPMENT

Purpose: The purpose of this addendum is to supplement the suggested wording in Exhibit 1 in order to establish a stability test for voice frequency repeaters. The supplier of the central office equipment with CMO must conduct and pass this test in order to guarantee the stability of the repeaters without connecting the switchboard to the outside plant. This procedure rsduces the time required for testing.

Additions: Add FIGURE 5.

Add to Exhibit 1.

3. OPERATIONAL REPEATER STABILITY TEST

3.1 The central office equipment groups which incorporate common mode operation with voice frequency repeaters shall pass the following test as shown in FIGURE 5 of REA TE & CM-331, "Application of Common Mode Operation to Central Offics Equipment," in order to be accsptable:

3.11 A call from an artificial line consisting of a 500 type telephons inetrument, two eections of FIGURE 5C and five sections of FIGURE 5B to the CMO line equipment, and dialing a CMO connector terminal. The CMO connector terminal will look into an identical artificial line of five sections of FIGURE 5B plus two sections of FIGURE 5C to a 500 type telephone set.

3.12 On all calls made in this manner with voics frequency repeaters in ths linefinder and connector there is to bs no singing of repeaters at any point in the progrsss of the call from origination through convereation and complete release of both partiee.

3.2 The above test ie in addition to other tests required in REA Bulletin 384-2, "Closeout Documsnts for Central Office Equipment Contracts," REA Bulletin 383-2, "Pretesting Inepections and Acceptance Tests - Outside Plant," and REA Form 397a, "Specification for Voice Frequency Repeaters and Voice Frequency Repeatersd Trunks."

THE APPLICATION OF COMMON MODE OPERATION TO CENTRAL OFFICE EQUIPMENT

CONTENTS

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, and other interested parties with technical information for use in the design and engineering of REA borrowers' telephone systems. It refers specifically to the application of the principle of sharing long line adapters and voice frequency repeaters within the switching systems of REA borrowers. This method of sharing adapters and repeaters is called "Common Mode Operation (CMO)."

2. DESCRIPTION OF SYSTEM

2.1 If subscriber loop plant is designed for the use of 22- and 24-gauge cable, each loop, if long enough, will require a long line adapter (LLA) and an E-6 type voice frequency repeater (VFR). The cost of the LLA and VFR may make their use unattractive and the designer will resort instead to cable of a coarser gauge or carrier.

2.2 The "Common Mode Operation" places the adapter, and repeater if required, within the switching system. This allows each long line to share the cost of a reduced number of long line adapters and voice frequency repeaters. This in turn permits the designer to use the finer gauge cables instead of 19-gauge cable to a much greater extent.

2.3 Dedication of Line Groups

2.31 The "Common Mode Operation" dedicates one or more linefinder groups and one or more connector groups to the exclusive use of long lines. The adapters and repeaters are placed between the linefinders and first selectors of the dedicated linefinder groups and repeaters are also used in conjunction with the connectors in the dedicated connector groups. Thus, the number of adapters required may be reduced to 15 or 20 percent and the number of repeaters to 30 or 40 percent of the long lines served.

2.32 It is possible to arrange subgroups of lines within a dedicated linefinder group to switch in the long line equipment only if required. This arrangement provides flexibility in permitting both long and short lines to be placed within a dedicated group.

2.4 The "Common Mode Operation" consists of the following:

2.41 Placing the long line adapter and the E-6 type repeater (or just an adapter) between every linefinder and first selector in a linefinder group dedicated to CMO lines.

2.42 Placing a repeater (if required, as described later) in conjunction with every connector in a connector group dedicated to CMO lines.

2.43 Placing elevated d.c. voltages in the following places to extend the loop range:

2.431 The line relays for land-in and for talking battery on reverting calls if applicable.

2.432 The long line adapter.

2.433 The connector called party's supervisory relay.

2.434 The ring trip circuitry within the connector.

...4 Making certain changes and modifications of the central office equipment, which will be described later, to prevent repeater singing and to ensure proper equipment operation.

...5 It will be noted that special treatment of first selectors, second selectors, trunks, etc. is not necessary for CMO. The pulsing and supervision is accomplished in the long line adapter on calls originated by long lines which permits the use of selectors and trunks without change.

...6 Comparison of the number of long line adapters and voice frequency repeaters necessary on each line and on CMO is as follows: (traffic is increased by 25 percent in accordance with paragraph ...6).

...61 25 lines (conventional operation requires 25 adapters; as many as 25 repeaters)

	25 lines/25 terminals	25 lines/50 terminals	25 lines/100 terminals
Originating Traffic	1 unit call/line	1.8 unit call/line	2.5 unit call/line
Terminating Traffic	.9 unit call/term.	.8 unit call/term.	.7 unit call/term.
Number of LLA's	4	5	6
Number of VFR's	8	10	13
Savings LLA's	21	20	19
Savings VFR's	17	15	12

...62 50 lines (conventional operation requires 50 adapters; as many as 50 repeaters)

	50 lines/50 terminals	50 lines/100 terminals	50 lines/200 terminals
Originating Traffic	1 unit call/line	1.8 unit call/line	2.5 unit call/line
Terminating Traffic	.9 unit call/term.	.8 unit call/term.	.7 unit call/term.
Number of LLA's	6	8	10
Number of VFR's	11	15	24
Savings LLA's	44	42	40
Savings VFR's	39	35	26

...63 100 lines (conventional operation requiree 100 adaptsre; as many as 100 repeaters)

	100 lines/100 terminals	100 lines/200 terminals	100 lines/400 terminals
Originating Traffic	1 unit call/line	1.8 unit call/line	2.5 unit call/line
Terminating Traffic	.9 unit call/term.	.8 unit call/term.	.7 unit call/term.
Number of LLA's	9	13	16
Number of VFR's	17	27	44
Savings LLA's	91	87	84
Savings VFR's	83	73	56

3. APPLICATION OF COMMON MODE OPERATION (CMO)

3.1 The objective of CMO is to permit more extensive use of fine gauge cable in outside plant, thereby conserving copper and reducing costs. The two basic devices used to achieve this objective are the LLA and the E-6 type VFR.

3.2 CMO is applicable to either new or existing switchboards.

3.3 Because a linefinder group and a connector group must be dedicated to long lines, the central office probably will have at least two groups of linefinders and connectors. As many more groups as needed may be used.

3.4 In making the determination as to whether the application of CMO to a particular office is desirable, it should be understood that means are now available for providing new central office equipment that will accommodate 1700 ohms of outside plant, without long line adapters, if the voltage is stabilized. If the office in question has approximately 50 lines or more requiring long line adapters or long line adapters and voice frequency repeaters when designed with 22- and 24-gauge cable, it is a candidate for the application of CMO.

3.5 If the central office equipment is to be retained, and if it is of an older vintage which originally required an outside plant design of 1025 ohms, there are means to modify many of these central offices to work with 1700-ohm buried plant. However, such a central office may be an excellent candidate for CMO, placing all lines beyond 1025 ohms in the dedicated groups. In other words, it may be more economical to implement CMO than to modify the equipment for 1700-ohm operation.

3.6 If the central office equipment is to be retained, the CMO conversion should be made in the factory on any new addition.

3.7 CMO is applicable to both terminal-per-line and terminal-per-atation offices.

3.8 In order to apply CMO to a central office the subacriber lines being served must be divided into categories. A category includes those lines whose range of resistance and other characteristics permit them to be treated identically at the central office. The lines which are not in CMO groups are, of course, one category of lines. This identical treatment may include such items as long line adapters and elevated voltages, but primarily the same level of voice frequency amplification. The minimum size group which shares identical equipment in the CMO concept is a hundreds group of lines. Therefore, a category must, at the leaat, consist of all the common equipment to serve a hundred lines, and enough paths to handle the traffic gsnerated by the number of lines equipped in the group. In order to avoid unnecessary costs in central office equipment plus a continuing administrative problem in the working syatem, sach CMO office should rarely contain more than two categories of lines and never more than three.

3.9 As mentioned earlier an entire linefinder group must be dedicated to long lines. Since the typical linefinder switch in some step-by-step equipment accommodates 200 lines, it may be difficult to match the number of long lines with either the number of lines in a partially equipped group or a fully equippsd group. Linefinders which will accommodate 100 lines are available and may be used where a saving is realized.

4. TRAFFIC

4.1 Thsre are reasons why unusual traffic problems might be encountered in the CMO. They are as follows:

4.11 In typical terminal-per-station offices it is possible to shift lines from group-to-group in order to balance the traffic load. With CMO one or more linsfinder and connector groups are dedicated to long lines and balancing the traffic load can only be done within the same category.

4.12 Traffic studies made on a large number of individual singls party lines have indicated a tendency toward increased usage as the distance from the central office increasss. Since the CMO puts the longest lines in the same group, it follows that those groups would offer unusually heavy traffic.

4.2 For the present it is suggested that traffic eatimates based on average calling rates be increased for the dedicated groups by approximately 25 percent for the purpose of determining the number of linefinders and connectors required.

4.3 It should be noted that it is not wholly imposaible to shift traffic out of the dedicated groups. Long lines moved to nondedicated groups may be treated with individual long lins adapters and voice frequency repeaters. Short lines should not be moved into dedicated groups, unless they are given apecial treatment by aubgroups aa mentioned in Paragraph 2.32.

5. POWER SUPPLY

5.1 For purposes of reliability a spare booster power supply should be used to guard against complete CMO failure. In CMO the loss of booster aupply blocks entire groups of lines. The spare booster supply should automatically awitch into the circuit if an operating booster supply should fail.

5.2 It is recommended that the power supplies be solid atate d.c. to d.c. converters operating from the central office battery.

5.3 The output of the power supply required for battery feed relays should be adequate for the number of CMO lines wired.

5.4 It is preferable to use 48 or 60-volt booaters for a total value of elevated voltage of 96 or 108 volts.

6. RINGING

6.1 For ringing on long loops it is rsquired that PE-40 (REA Bulletin 345-30, "REA Specification for Ringing Generator Equipment") type ringing machines bs uaed.

[illegible] beyond 2000 ohms use only ringers accepted in REA Bulletin 344-2, "List of Materia[illegible] Acceptable for Use on Telephone Syatems of REA Borrowers," for service on loops from 2000 t[illegible] These ringers which operate to 3000 ohms in the worst case (19-gauge cable) will oper[illegible] shorter loop resistances with 22- and 24-gauge cable because of the lower cable capacitsnc[illegible] Further information on ringing over long loops can be found in REA TE & CM-212, "Ringin[illegible]

[illegible]

[illegible] design is contained in REA TE & CM-429, "Deaign of Two-Wire Subscriber Loop Pl[illegible] Mode Operation."

[illegible] plant signaling limits on new equipment are as follows:

Circuits up to	Require
1325 ohms	Regular operstion
1700 ohms*	Stabilized central office battery 51-52 volts
4300 ohms*	48 or 60-volt booster power supply on CMO line

*Subtrsct 12 percent for aerial plant.

[illegible] limits reusing old central office equipment for CMO are as follows:

[illegible] signaling limits must be reduced to the actual capability of the equipment. Exact limi[illegible] will vary somewhat, but assuming the central office equipment was built to a guarsntesd 120[illegible] [illegible], [illegible] the instrument, the following outside plant signaling limits may be used for desig[illegible]

Circuits up to	Require
1025 ohms	Regular line
3000 ohms	48-volt booster power supply on CMO line

[illegible] There are so many different typss of central office equipment in service that it is impossibl[illegible] to give complete information concerning these limits. In many cases, additions to existing equipment incorporate greatsr capabilities. If the additions are used for dedicated connectors, the[illegible] CMO loops may be extended in the rsnge of those shown in Paragraph 7.2. Also, the use of central office battery voltage stabilizing devices and the use of buried plant will extend the signaling limits.

[illegible] The pulsing limits of CMO are controlled by the capability of the long line adapters. The information on existing adapters is by no means complete, but tho indications are that most modern adapters have a range of 3000 ohms outside plant at 72 volts and 4300 ohms outside plant at 96 or 192 volts. Older type adapters may have less range.

[illegible] SPECIAL CMO CIRCUIT CONSIDERATIONS

8.1 Figures 1, 2, 3, and 4 show bssic differences in CMO circuits ao compared to regular central office equipment circuits used for atandard loops. These figures are for reference only.

8.2 With regard to the CMO connector in Figure 4, it is, of course, impossible to incorporate in one drawing all the possible vsriations in circuitry. In the design of a particular connecto[illegible] the following items have bearing on exactly where the repeater is inoerted:

8.21 CMO is designed to avoid ringing through tha connector repeater as it reduces ringing voltag[illegible] slightly.

8.22 The repeater is snergized by means of tha ring trip ralay. This avoids repeater singing before answer. If it were turned on by the answer ("called party") relay, it would be "dead" [illegible] calls to intercept.

8.23 The repeater is placed so that ringback tona, busy tone, and reverting call tone do not have to pass through a "dead" repeater. Tones applied during talking condition, such as conver[illegible] sation timing tone, can be on either side of the repeater.

8.24 Booster voltages are to be placed in series with the ground aide of the battery feed coils.

9. MISCELLANEOUS

9.1 Automatic Number Identification (ANI) using special station equipment which passes d.c. signals from the instrument to the DDD equipment cannot be used with most presently available long line adapters. Direct Distance Dialing (DDD) calls from long party lines will use operator number identification. However, one supplier has a long line adapter which will pass identification signals for two-party lines (tip party marking).

9.2 Do not put paystations in CMO groups.

9.3 PABX lines which have special arrangements for avoiding collision of incoming and outgoing calls should also have their own long line adapters designed to provide this special feature.

9.4 FX (Foreign Exchange) lines should not be placed in the CMO group.

9.5 One of the advantages of putting the long line adapter within the switching system is that remote testing devices which use the test distributor and test connectors to reach the line can test lines which need long line adapters. In conventional systems, the testing device cannot make remote tests on such lines because the long line adapter appears between the test connector and the outside plant.

9.6 There is also the possibility when less than 20 lines fall in any CMO category that these lines be treated in the conventional manner with long line adapters, or long line adapters and voice frsquency repeaters, per line.

10. SPECIFYING CMO (APPLICATION GUIDE FOR EXHIBIT NO. 1)

10.1 To specify CMO on a new switchboard it is advisable to follow the suggested wording in Exhibit No. 1.

10.2 Item 1.3

10.21 Strike out either Bidder or Owner depending on who is to furnish the E-6 type repeaters in conjunction with the dedicatsd linefinders and connectors. If the Owner is to supply the repsaters, he must complete a "Supplement A" to the Central Office Equipment Contract and insert it immediately following Page 2 of the contrsctor's propossl.

10.3 Item 2.1 - Category of Lines No. 1

10.31 The maximum signaling range of these lines should agree with the guaranteed loop resistance in Part I of the "General Specifications," REA Form 558a. Mark Yes or No to show whether the Owner is to supply a standby engine generator. This will enable the central office equipment supplier, who requires float voltage to guarantee his equipment at 1900 ohms, to determine whether he will have to bid voltage stabilization equipment or not. The number of lines and terminals equipped and wired sre the number which will not be in the CMO groups. The number of lines which exceed the guaranteed loop limit of the central office equipment, but are not in CMO groups is used to determine the number of long lines requiring individual long line adapters and voice frequency repeaters, if required.

10.4 Item 2.2 - Category of Lines No. 2
Item 2.3 - Category of Lines No. 3

10.41 These categories are the ones which will incorporate the CMO principle. They will cover outside plant resistance ranges in accordance with transmission requirements. The signaling range for each CMO category will extend to 4500 ohms. The transmission range will be different for each CMO category and will be determined by the parameters as given in REA TE & CM-429, "Design of Two-Wire Subscriber Loop Plant - Common Mode Operation." Design effort should be made that long lines will have characteristics so similar that only one category of CMO will be required. This, of course, is most desirable for administrative purposes. The repeater gain setting is determined by the physical make up of the outside plant which is being served by the category. If no repeaters are required, insert the word "none" in the blank for repeater gain setting. The traffic should be calculated in the regular manner if it is not measured. The preferable method is to determine the traffic by actual measurement, but if this cannot be done, use the guidelines set forth in REA TE & CM-325, "Application Guide for ths Preparation of Detailed Dial Central Office Equipment Requirements," and increase by 25 percent.

Item 2.

1. This division of lines is for information only. It represents an overall review of the design and exposes any problems which may arise in the assignment of line groups into th[illegible] material.

2. To specify CMO on an existing switchboard it is advisable to follow the same items as specifying a new switchboard. In Item 2.1 of Exhibit 1 the maximum range of the regular [illegible] office is to be determined by test of the actual equipment. See Addendum No. 2 of REA [illegible], "Expansion of Existing Dial Central Office Switchboards," for test instructions.

3. It must be kept in mind that if existing equipment is used for CMO groups and is not a [illegible] office, then the signaling range of the equipment cannot be beyond 3200 ohms with [illegible] booster battery.

EXHIBIT 1

SUGGESTED WORDING FOR INSERTION OF COMMON MODE OPERATION IN "EXPLANATORY NOTES" OF THE CENTRAL OFFICE EQUIPMENT SPECIFICATION, REA FORM 558, PART III

1. The Biddar shall arrange his equipment for Common Mode Operation. One or more linefinder groups and connector groups shall be arranged for operation beyond the regular loop range of the central office.

1.1 The Bidder shall furnish the necessary equipment and power supplies to supply booster power of 48 or 60 volts for the purpose of land-in, signaling, talking battery, and ring trip during silent and ring period. This voltage should be applied in series with the ground side of the battery feed coils.

1.2 The power supplies shall be solid state d.c. to d.c. converters operating from 48-volt battery, adequately filtered, and of sufficient size to handle the number of long lines in question. The power supplies shall be furnished with a spare unit. In the event of failure of a primary unit, the standby unit will automatically assume the load.

1.3 The (Bidder) (Owner) shall furnish E-6 type voice frequency repeaters to be used in conjunction with dedicated linefinders and connectors which require them. (If the Owner elects to furnish the repeaters, a "Supplement A" to the Central Office Equipment Contract (REA Form 525) shall be completed in accordance with its terms and inserted following Page 2 of this Proposal). The Owner shall furnish any field mounted repeaters required.

1.4 For the purposes of determining the quantities of intraoffice traffic, the per line and the per terminal traffic specified in Part III, REA Form 558c, Item 11.02 and 11.03 shall apply to all nondedicated lines. The originating and terminating traffic of dedicated lines shall be shown with each CMO group. Also show on the switching diagram.

The Bidder shall supply the equipment designed and furnished so that all the customary central office features will be available to the dedicated long lines with the obvious exception that the long lines must be served by the dedicated groups.

1.6 Nothing in this specification may be construed to waive the self-protecting features in Part I of REA Form 558, Item 1.133.

2. Information for determining the number of categories and the number of line groups per category. All loop resistances include the telephone instrument.

2.1 Category of Lines No. 1

2.11 Regular Central Office Lines:

The maximum loop capability of the regular central office lines _____ ohms

Standby engine generator unit will be provided by Owner Yes _____ No _____

Number of Lines: Equipped _____ Wired _____

Number of Terminals: Equipped _____ Wired _____

2.2 Category of Lines No. 2 (Note 1)

2.21 Common Mode Operation:

Number of Lines: Equipped _____ Wired _____

Number of Terminals: Equipped _____ Wired _____

Maximum signaling range 4500 ohms

Resistance range intended for this category _____ to _____ ohms

Terminal voice frequency repeater gain setting _____ GUG (Note 2)

Originating Traffic _____ UC/L

Terminating Traffic _____ UC/T

[illegible]

Category of Lines No. 3 (Note 1)

[illegible]-Mode Operation:

Number of Lines: Equipped _____ Wired _____

Number of Terminals: Equipped _____ Wired _____

Maximum signaling range 4500 ohms

Resistance range intended for this category _____ to _____ ohms

Terminal voice frequency repeater gain setting _____ CUG (Note 2)

Originating Traffic _____UC/L

Terminating Traffic _____UC/T

The lines which are to be served by the central office equipment are divided in resistance ranges as follows:

Number of Lines	0 - 1200 ohms	_____
Number of Lines	1201 - 1500 ohms	_____
Number of Lines	1501 - 1700 ohms	_____
Number of Lines	1701 - 1900 ohms	_____
Number of Lines	1901 - 2200 ohms	_____
Number of Lines	2201 - 3200 ohms	_____
Number of Lines	3201 - 3400 ohms	_____
Number of Lines	3401 - 4200 ohms	_____
Number of Lines	4201 - 4500 ohms	_____

Note 1: When a CMO category consists of more than one group of lines, the lines shall be equally divided among the groups.

Note 2: Repeater gain setting for various resistances of outside plant and various types of outside plant are to be found in REA TE & CM-429, "Design of Two-Wire Subscriber Loop Plant - Common Mode Operation."

FIGURE 1
BASIC POWER SUPPLY CIRCUITRY

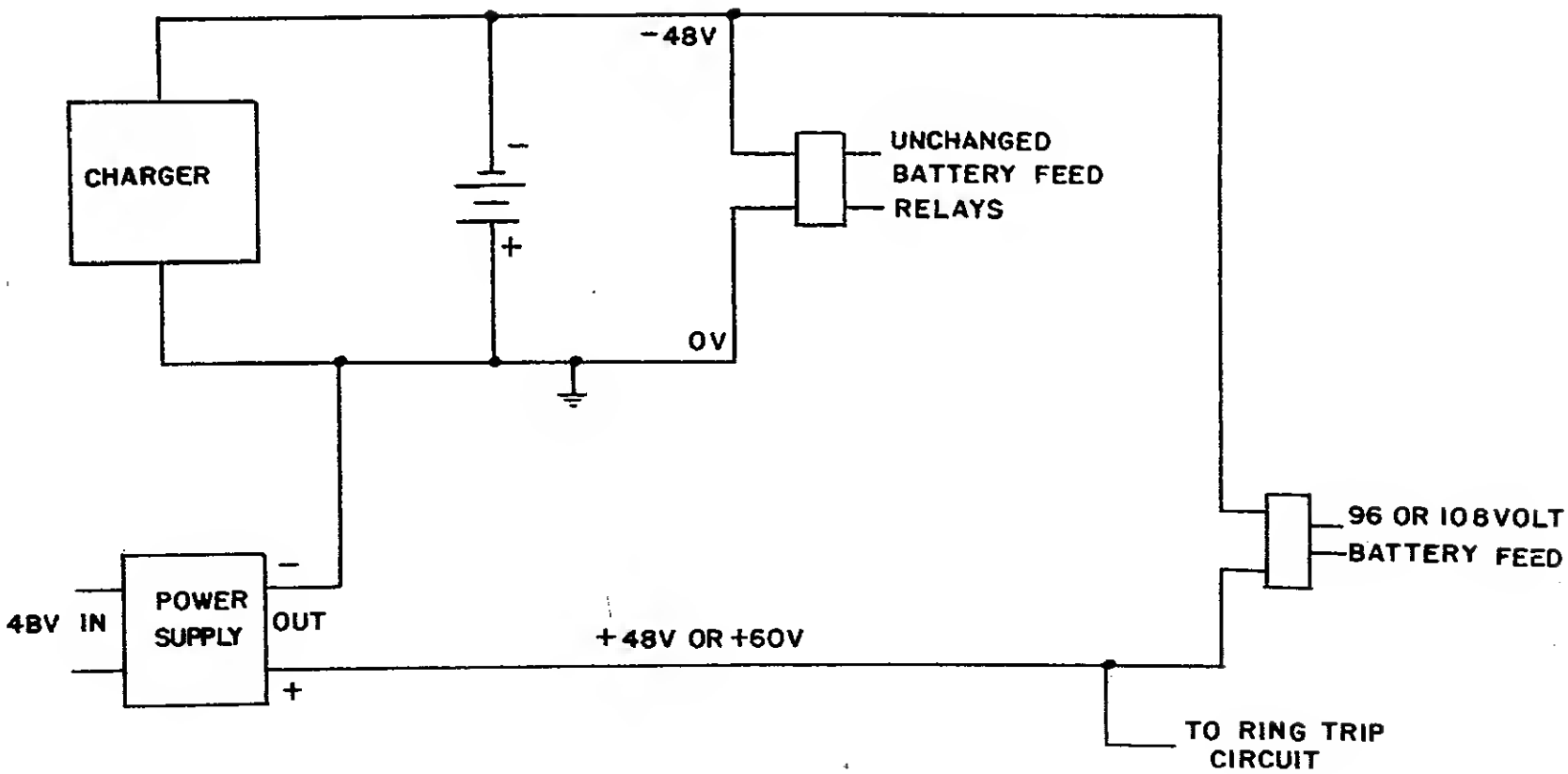

FIGURE 2
MODIFICATION OF LINE RELAY

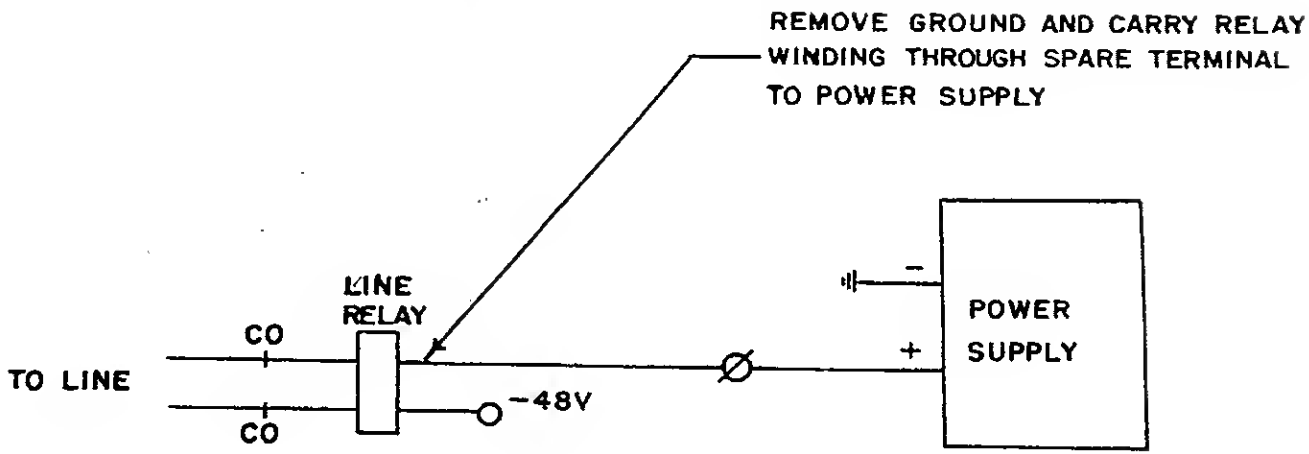

FIGURE 3

INSERTION OF REPEATER AND LLA BETWEEN LINEFINDER AND SELECTOR AND MODIFICATION OF LLA

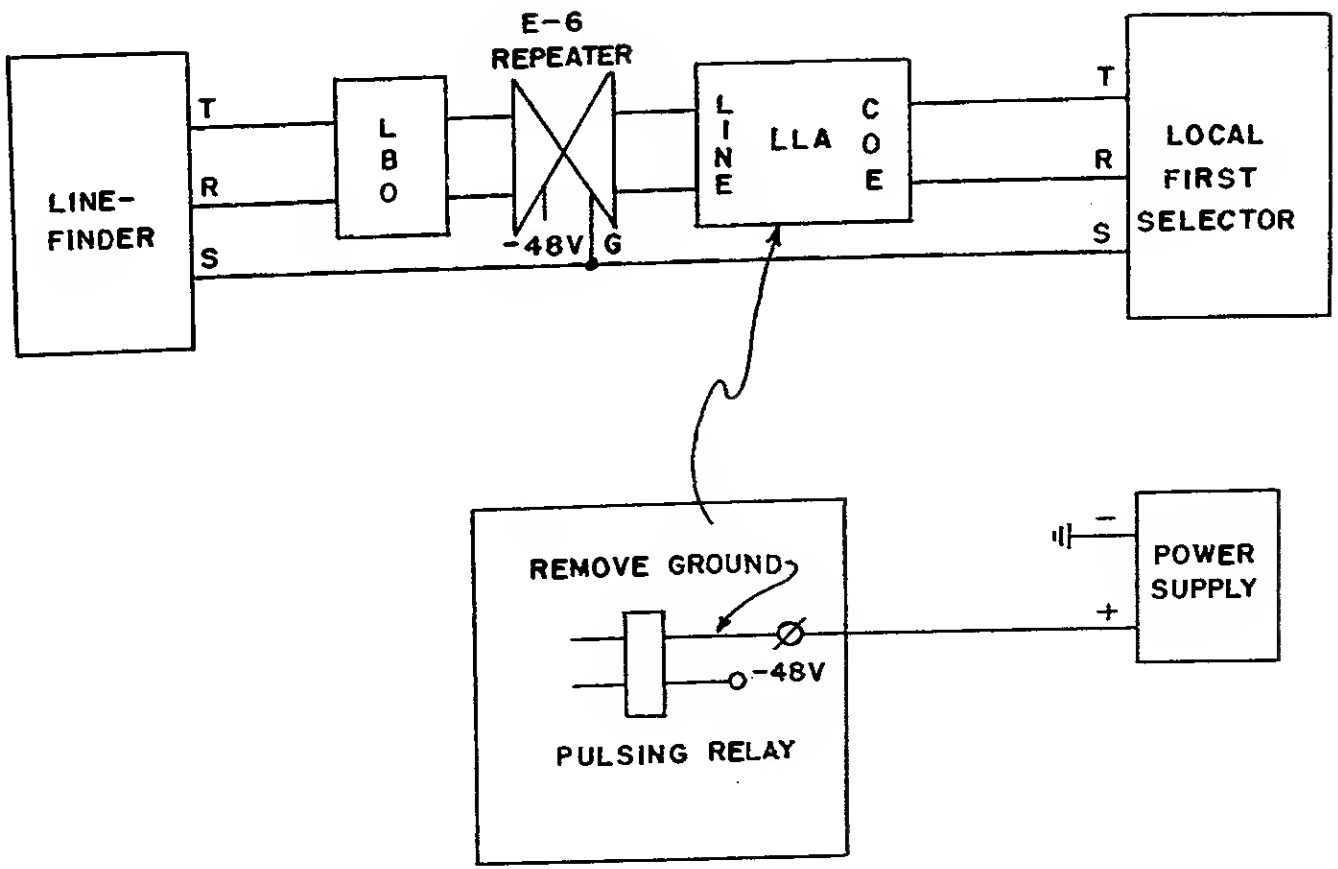

FIGURE 4

MODIFICATION OF CONNECTOR AND RINGING MACHINE

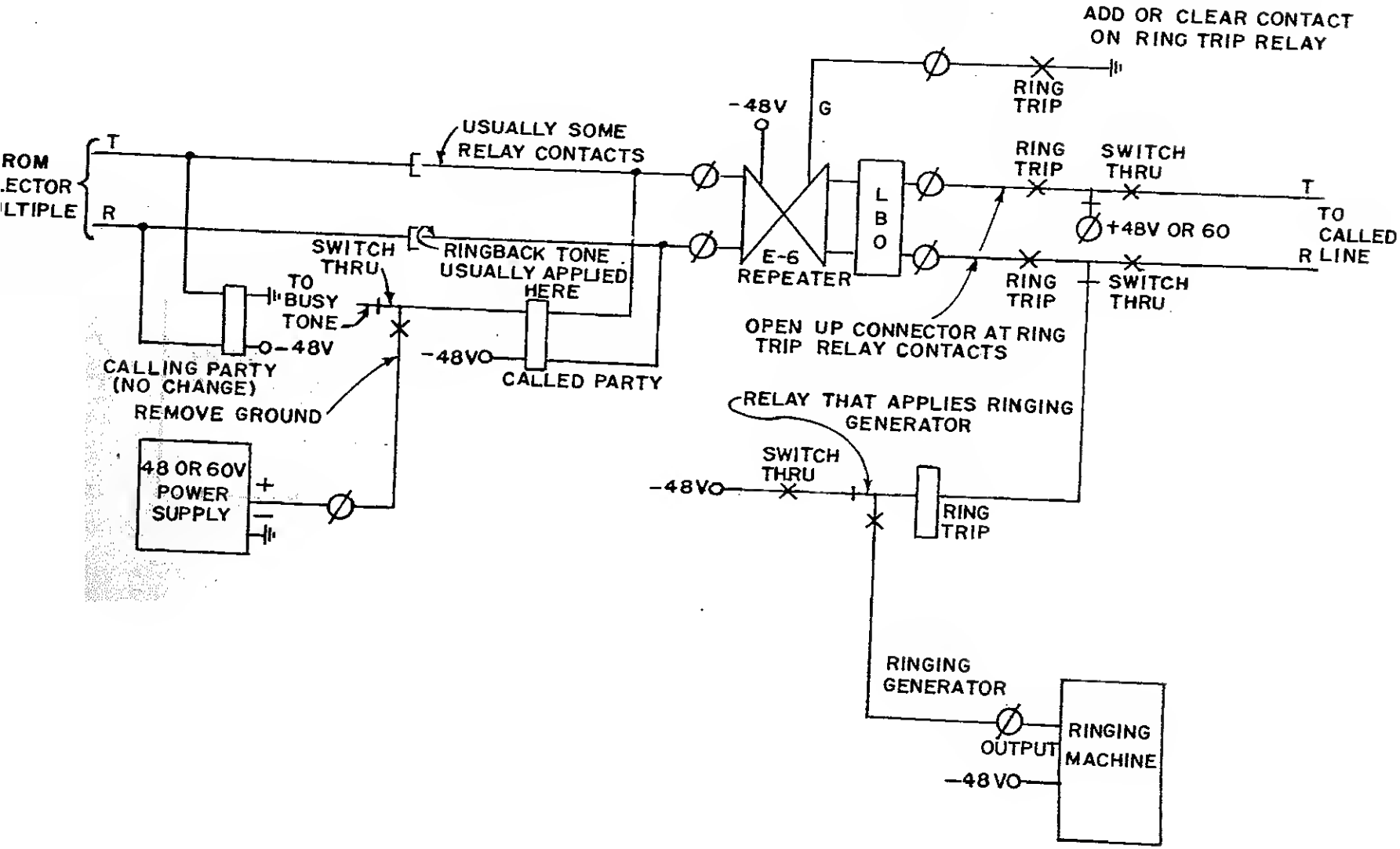

FIGURE 5

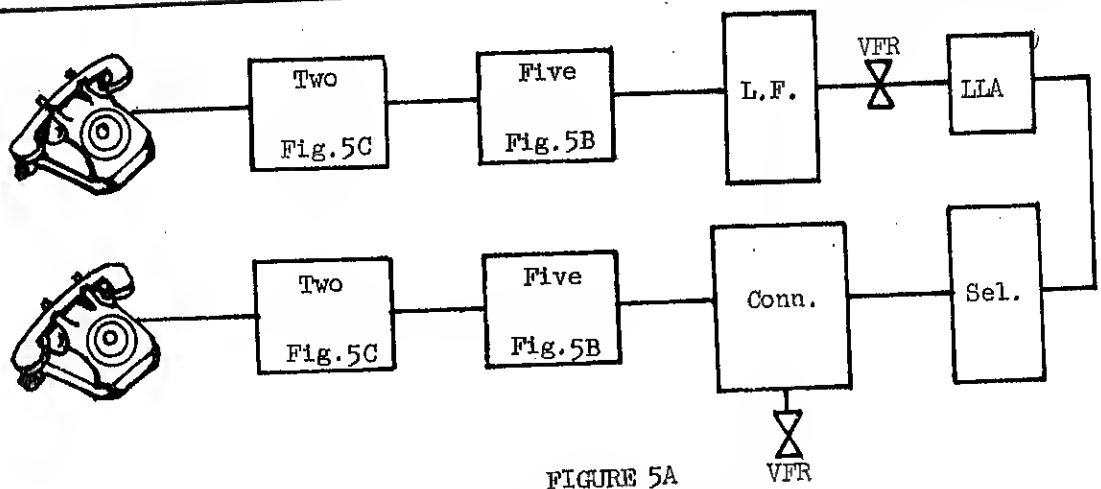

FIGURE 5A
TEST SET UP

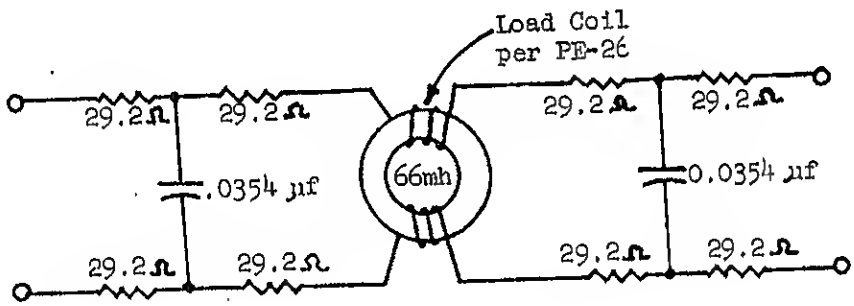

FIGURE 5B
CONFIGURATION FOR 4500 FEET 24-D-66 LOADED ARTIFICIAL LINE

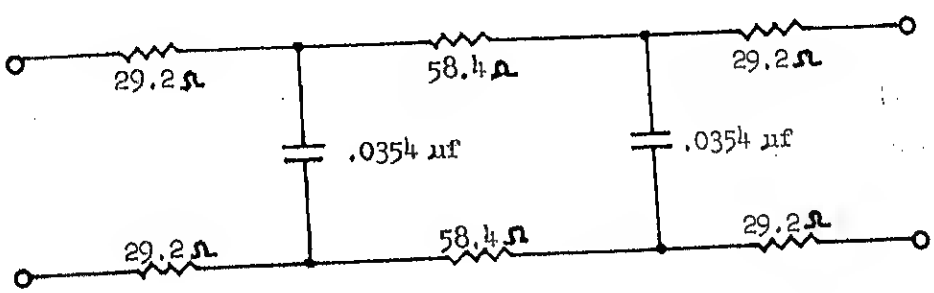

FIGURE 5C
CONFIGURATION FOR 4500 FEET 24-GAUGE NONLOADED ARTIFICIAL LINE